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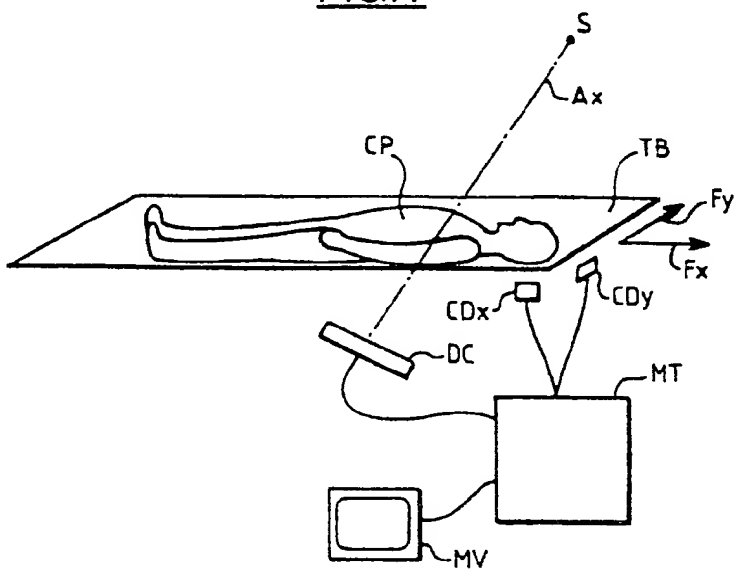
(54) Method for reducing X-ray noise

(57) For each acquired current image (X_{n+1}), the displacement (D) of said current image is determined relative to the acquired preceding image (X_n) in the image acquisition plane, a displaced preceding filtered image is elaborated by spatially displacing the preceding filtered image, taking said displacement into account, and the current filtered image is elaborated by the weighted average between the acquired current image (X_{n+1}) and the displaced preceding filtered image, so as to improve the quality of the images visualized.

FIG.1



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Description

[0001] The invention concerns the fluoroscopy and, in particular, the treatment of a sequence of fluoroscopic images of a body, particularly of a human body.

[0002] The invention further applies, in particular, to cardiac fluoroscopy.

[0003] By comparison with radiography in acquisition mode, where the X-ray doses are greater, in order to obtain better quality registered images for diagnostic purposes, fluoroscopy is carried out with weaker X-ray doses and is, in particular, used in the surgical field, for example, to position coronary endoprostheses ("stent" in English) by means of catheters.

[0004] In fluoroscopy the movement of the objects of interest, like, for example, coronary endoprostheses, as well as, notably, in cardiac fluoroscopy, the background movement, associated linked, for example, with the patient's respiration, as well as with the movements of the table on which the patient is placed, produce disturbances in the images, to which is added noise, particularly of electrical origin. That noise is all the more disturbing, the longer the fluoroscopic examination lasts, typically about 45 minutes, in order to position an intravascular prosthesis correctly, and produces, consequently, a visual inconvenience for the physician.

[0005] In the presence of immobile images, the noise could easily be eliminated by simple temporal filtering. However, in fluoroscopy mobile images are present which are translated, if a filtering of images (for example, a filtering by temporal means) is simply carried out by a blurred movement or else a loss of contrast of the mobile objects (depending on the size of the objects). In other words, there is then no difference between the arrival and departure of an object of interest and a noise peak.

[0006] At present, the standard algorithms of image processing in fluoroscopy resort to a criterion of distinction between a variation due to noise and a variation due to movement. The filtering treatment is then stopped or diminished in the presence of a movement. However, the cessation of filtering produces a recurrence of the noise, which is translated on the images by noise trails behind the mobile objects.

[0007] The invention is intended to offer a more satisfactory solution to these problems.

[0008] The invention therefore proposes a method of treatment of a sequence of fluoroscopic images of a body, comprising the acquisition of a sequence of images, the elaboration for each acquired current image of a current filtered image from the acquired current image and preceding filtered image, and visualization of the sequence of filtered images.

[0009] According to a general characteristic of the invention, for each acquired current image, the displacement of said current image is determined in relation to the preceding image acquired in the image acquisition plane, a so-called "displaced" preceding filtered image is elaborated, by spatially displacing the preceding filtered image, taking said displacement into account and the current filtered image is elaborated by the weighted average between the acquired current image and the displaced preceding filtered image, so as to improve the quality of the images visualized.

[0010] When the body is laid on a movable table, the displacement of said current image is advantageously determined in the plane of acquisition of the images from the displacement value of the table, the spatial orientation of the plane of acquisition relative to the table and the distance of that plane of acquisition relative to the table.

[0011] As a variant, one can also determine the displacement of said current image in the plane of acquisition of the images from the content of those acquired images.

[0012] The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:-

- Figure 1 schematically illustrates a system making possible a use of the method according to an embodiment of the invention; and
- Figure 2 schematically illustrates two successive acquired images.

[0013] In Figure 1, reference TB designates a table translatable in two orthogonal directions Fx and Fy by means of a crank, for example, not represented here for purposes of simplification. Displacement sensors CDx and CDy, of construction known per se, make it possible to determine the values of the displacements in directions Fx and Fy respectively and deliver that information to treatment means MT containing a microprocessor.

[0014] On the table TB, a patient CP is stretched out and undergoes a fluoroscopy examination. In that regard, the fluoroscopy apparatus contains an X-ray source S emitting X-rays along an axis Ax in the direction of a detector DC of standard construction known per se, also connected to the treatment means MT. The detector DC is a plane detector, forming the image acquisition plane. This plane is perpendicular to axis Ax. The detector DC and the source S form part of an apparatus containing an arm moving in space around the patient CP.

[0015] The orientation of the axis Ax is known perfectly at every moment, as is the distance between the table TB and the detector DC. The displacements in directions Fx and Fy of the table TB can therefore be easily converted in a standard manner known per se into displacements u and v in the plane of the detector DC, that is, in the image acquisition plane.

[0016] Reference is now made, in particular, to Figure 2. It can be seen that, on fluoroscopy examination, a sequence of images X_n is acquired, typically at the rate of 30 images per second. The pixel values of each

image are stored, as they are acquired, in a memory of treatment means MT, in order to permit image processing and, in particular, their filtering.

[0017] This being so, when in the course of the fluoroscopy examination the physician moves the table TB and/or the coronary endoprosthesis so as to keep the region of the body considered in the field of X-radiation, the object of interest (for example, the coronary endoprosthesis), which is very schematically represented under reference A in the image X_n, is moved from the displacement vector D into the following image X_{n+1} (PO and POD respectively representing the centers of the prosthesis in both images).

[0018] The displacement vector $\vec{D}$ has the coordinates u and v in the image acquisition plane, corresponding to displacement of the table in directions Fx and Fy (it is assumed here that only the table has moved).

[0019] The invention provides here for carrying out a filtering treatment by using, on the one hand, the current acquired image X_{n+1} and, on the other, not the preceding filtered image directly corresponding to the preceding acquired image, but a displaced filtered image YD.

[0020] More precisely, one implements in the microprocessor recursive law (1):

$$Y_{n+1} = (1-a)X_{n+1} + a\,YD_n \qquad (1)$$

in which Y_{n+1} represents the current filtered image, X_{n+1} the current acquired image, YD_n the preceding filtered image displaced relative to the preceding filtered image Y_n and "a" a weighting coefficient, typically equal to 0.2 (and possibly a function of X_{n+1} and of YD_n).

[0021] The law (1) is translated for each pixel of coordinates i,j in the image acquisition plane by law (2):

$$y_{n+1}(i,j) = (1-a)\,x_{n+1}(i,j) + a\,y_n(i-u, j-v) \qquad (2)$$

[0022] In other words, for each pixel of coordinates i,j of the acquired current image, the coordinates I, J of the displaced pixel are calculated in the preceding filtered image, taking into account the movement of the table ($I = i-u$, $J = hj-v$), and law (2) is applied.

[0023] The successive filtered images Y_{n+1} are successively displayed on the means of visualization MV of the fluoroscopy device.

[0024] When coordinates I and J are negative, that is, when there is no equivalent in the preceding image for a portion of the outlet image Y_{n+1}, that image portion is darkened. In other words, the values $y_{n+1}(i,j)$ are fixed at zero.

[0025] This darkening is not visible, taking into account the frequency of acquisition of the images and the customarily rapid movements of displacement of the table. In practice, it has been observed that this darkening is not visible when it does not exceed 10% of the image for the most rapid displacement movement.

[0026] In the mode of use just described, the coordinates u and v are determined from the movement of the table. This being so, it is also possible as a variant to calculate the coordinates u and v of displacement vector $\vec{D}$ directly between two acquired successive images by standard algorithms of detection of movement, by using, for example, the maximum criterion of correlation between two environments of two homologous pixels.

[0027] Materially, the displacement of filtered images is very simply carried out by using the delay elements connected to the lines and columns of the image storage memory.

Claims

1. A method of treatment of a sequence of fluoroscopic images of a body, comprising the acquisition of an image sequence, the elaboration for each acquired current image (X_{n+1}) of a current filtered image (Y_{n+1}) from the acquired current image (X_{n+1}) and from the preceding filtered image, and visualization of the filtered image sequence, wherein for each acquired current image (X_{n+1}) the displacement ($\vec{D}$) of the current image is determined relative to the acquired preceding image in the image acquisition plane, a displaced preceding filtered image (YD_n) is elaborated by spatially displacing the preceding filtered image (Y_n), taking the displacement into account, and the current filtered image (Y_{n+1}) is elaborated by the weighted average between the acquired current image (X_{n+1}) and the displaced preceding filtered image (YD_n), so as to improve the quality of the images visualized.

2. The method according to claim 1, in which the body is laid on a movable table (TB), wherein the displacement of the current image is determined in the image acquisition plane (DC) from the value of displacement of the table (TB) and spatial orientation and distance of the acquisition plane relative to the table.

3. The method according to claim 1, wherein the displacement ($\vec{D}$) of the current image is determined in the image acquisition plane from the content of the acquired images.

FIG.1

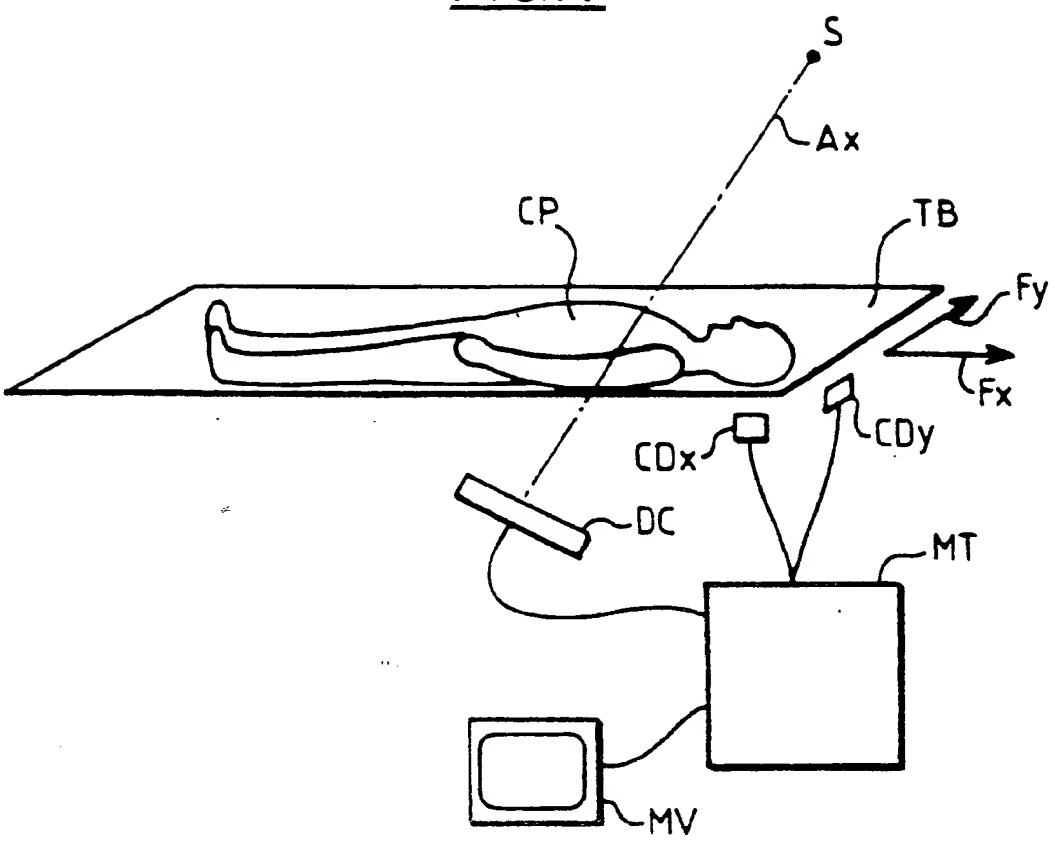
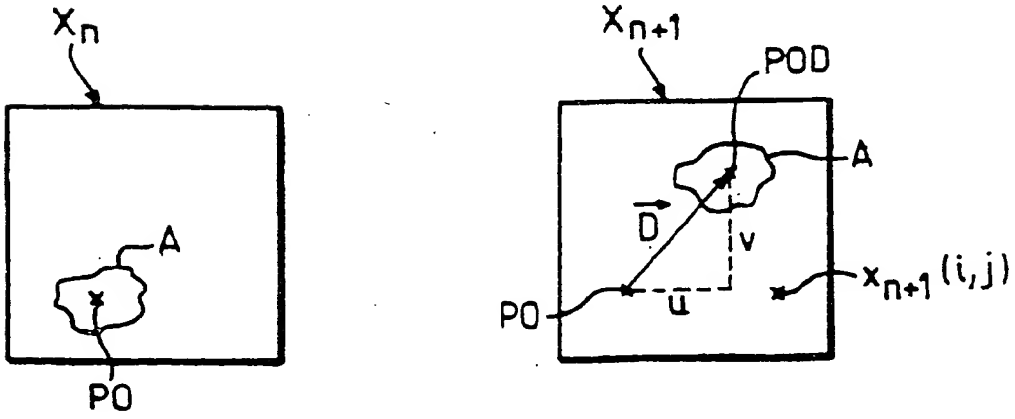


FIG.2



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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 1211

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	AUFRICHTIG R ET AL: "X-RAY FLUOROSCOPY SPATIO-TEMPORAL FILTERING WITH OBJECT DETECTION" IEEE TRANSACTIONS ON MEDICAL IMAGING, vol. 14, no. 4, 1 December 1995 (1995-12-01), pages 733-746, XP000548591 ISSN: 0278-0062 * abstract * * page 734, paragraph 2 * * page 736, paragraph 3 * -----	1,3	G06T5/00

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

G06T

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	26 April 2000	González Arias, P

CATEGORY OF CITED DOCUMENTS

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